

Distribution of the Bending Magnet Radiation

This note describes the distribution of the synchrotron radiation from the bending magnets (BM) in storage ring of the 6 GeV Light Source.

The total radiated power, $P_T(W)$, from one BM is given by

$$P_T = 1.263 E^2 B^2 I L = 10.44 \times 10^3 \text{ W}, \quad (1)$$

where E (position beam energy) = 6.6 GeV, B (magnetic field) = 0.88 T, I (beam current) = 100 mA, and L (BM length) = 2.45 m are used in this note. The radiation power density is approximately expressed as

$$P_D = 12.395 E^4 B I F(\gamma\psi) \text{ W/(mrad)}^2, \quad (2)$$

where $F(\gamma\psi) = 0.4375 e^{-\frac{1}{2}\left(\frac{\gamma\psi}{0.608}\right)^2}.$

The distribution of the radiation in the vertical direction in Eq. (2) is $\psi \sim 0.1$ mrad. Since there are 64 BM's in the storage ring, the maximum bending angle by one BM in the horizontal direction is

$$\theta_{\max} = 2\pi/64 = 98.175 \text{ mrad},$$

and the radiation per unit horizontal angle by one BM is simply

$$P_T/\theta_{\max} = 106.6 \text{ W/mrad}.$$

Figure 1 shows the distribution of the radiation per unit length (W/mm) in the vacuum chamber wall integrated over the vertical angle ψ , which is calculated from P_T/θ_{\max} . The bending magnets BM1 and BM2 are located immediately in front and behind the insertion device (ID) in the long straight section. The distance in the horizontal axis is along the positron beam orbit starting from the beginning of BM1. The curves of B1 and B2 in Fig. 1 are radiations from BM1 and BM2, respectively. All the solid curves are obtained

assuming that the vacuum chamber wall is 30 cm away from the beam orbit. The maximum radiation per unit length in the vacuum wall in this case is less than 2.5 W/mm. The dotted lines in Fig. 1 correspond to the case when the distance from the beam orbit to the vacuum chamber wall in the ID region is 2.5 cm. The maximum radiation per unit distance in this case of the ID region is less than 1.9 W/mm.

The radiation from BM1 (curve B1 extends from the distances of (4.3 ~ 12.7)m and that from BM2 (curve B2) to the distances of (12.6 ~ 0 ~ 4.3)m. It is interesting to note that there is no overlapping region of the two radiations. The two radiations will start to overlap when the distance of the vacuum chamber wall from the beam orbit is larger than 30 cm.

The absorptions by "crotches" (or absorbers) and their locations are shown in Fig. 2. The absorption (%) in the vertical axis is the fraction of the total radiation of 10.44 kW by one BM at 6.6 GeV. (Here the absorption simply means that the radiation from the BM hits the crotches. It may be absorbed by the crotches or reflected into the vacuum chamber.) Crotches of A1, B1, and C1 absorb the radiation from BM1, and those of A2, B2, and C2 from BM2. Crotch A1, which is located just after BM1, absorbs 61% of the radiation from BM1, the remaining 39% is absorbed by B1 (33.5%) and C1 (5.5%). This means that with the crotches of A1, B1, and C1, the radiation from BM1 does not hit the vacuum chamber wall at all.

The radiation from BM2 is absorbed by A2 (65.7%) and B2 (27.1%). The remaining 7.2% goes to C2. (Note that the direction of the radiation from the ID is between A1 and C2.) When the vacuum chamber wall in the ID region is 2.5 cm away from the beam orbit, 5.2% of the BM2 radiation will hit the wall in the ID region, and the remaining 2% goes to C2.

Table 1 summarizes the absorptions by the crotches. The absorption angle in the table is the angular range of the absorption by each crotch. There the forward direction of each BM is used as the reference direction. The lower values of the absorption angle are from the assumption that the edge of the crotches are 3 cm away from the beam orbit. In determining the widths of the

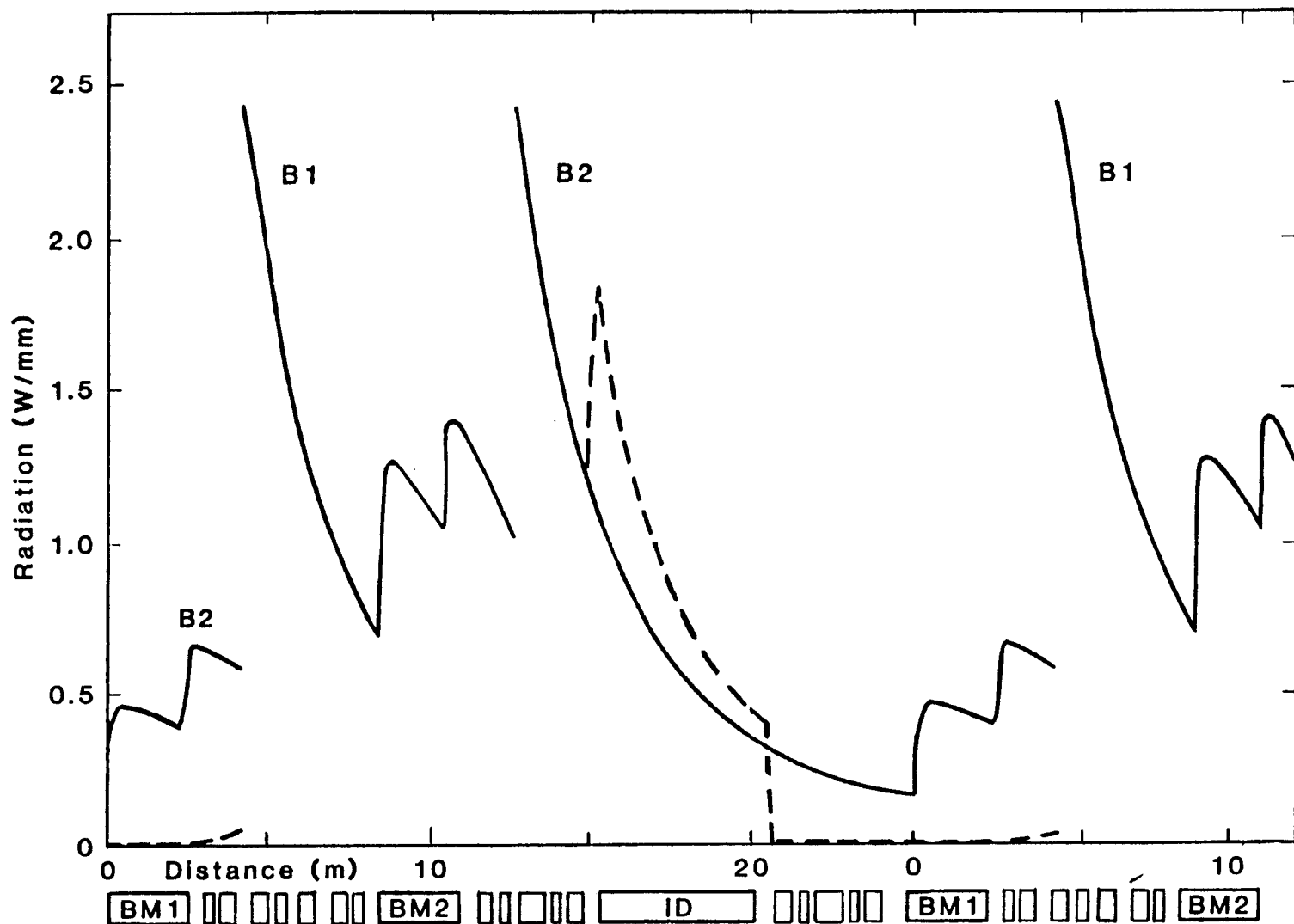


Fig. 1. Distribution of the BM radiation. The radiation (W/mm) is for per unit length along the distance of the vacuum chamber wall. The curves of B1 and B2 are the radiations from BM1 and BM2, respectively. All the solid lines assume that the vacuum chamber wall is 30 cm away from the beam orbit. The dotted line in the part of B2 is the case when the vacuum chamber wall in the ID region is 2.5 cm away from the beam orbit.

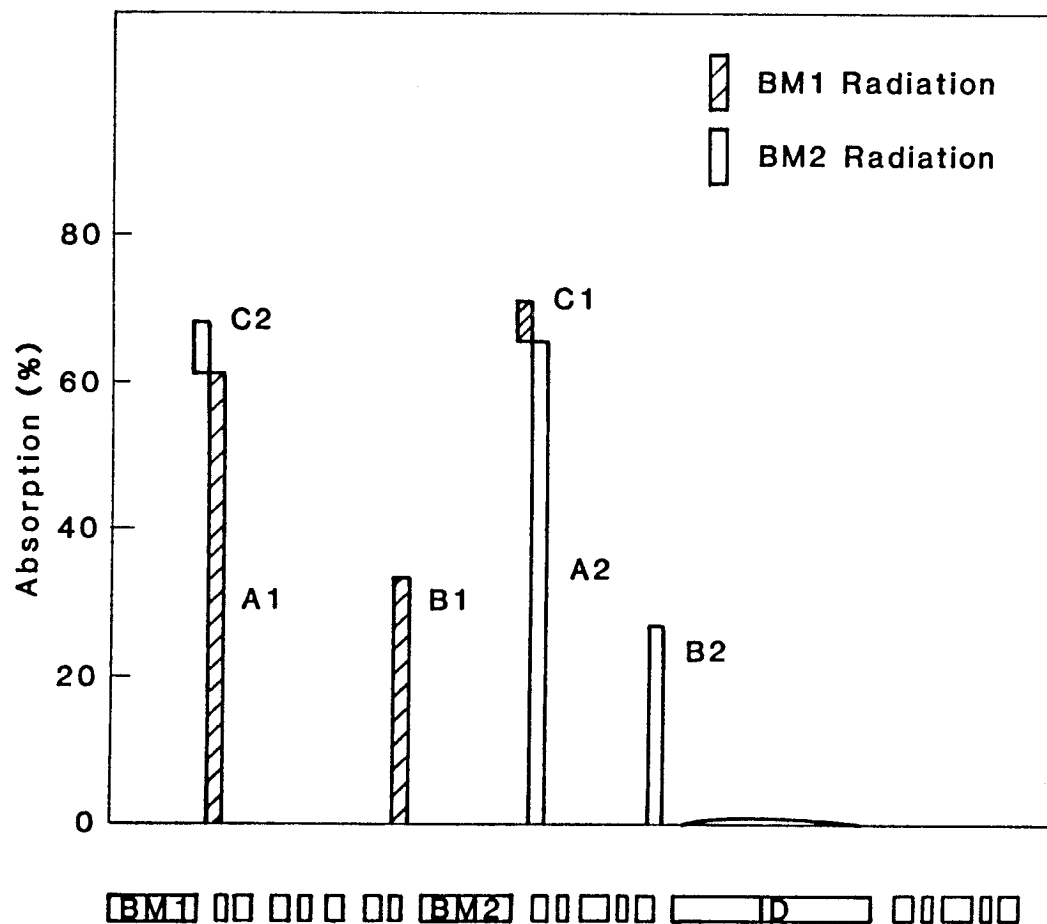


Fig. 2. Absorptions and locations of the crotches. Crotches A1, B1, and C1 absorb 100% of the radiation from BM1. The radiation from BM2 is absorbed by A2, B2, and C2. For the case when the vacuum chamber is narrow in the ID region, approximately 5% is absorbed in the ID region.